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Analytical Tools and Information

Volume 4

Critique of Land Management Planning

Analytical Tools and Information

Volume 4

Prepared by:

Thomas W. Hoekstra (Team Leader)
Gregory S. Alward
A. Allen Dyer
John G. Hof
Daniel B. Jones
Linda A. Joyce
Brian M. Kent
Robert Lee
Randall C. Sheffield
Robert Williams

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Executive Summary

The objectives of the study discussed in this report were to—

- Determine whether the Forest Service had the information necessary to produce quality national forest plans.

- Determine the effectiveness of the analysts and the planning analysis tools and procedures for developing the information needed for forest planning.

- Recommend the kinds of information that should be used in forest plan revisions, with attendant recommendations on analyst skills and analysis tools and processes.

Questionnaires were sent to appropriate region and national forest personnel to help gather information on their experience in using and conducting forest planning analyses, in information content and accuracy, and in the adequacy of analyst skills and training. A similar set of questions was mailed to approximately 175 individuals outside the Forest Service who had indicated an interest in this topic. Two workshops were held for economics and resource production analyses to complement the FORPLAN symposia that were held in 1986. From the questionnaires, workshops, symposia, and a review of the literature, the study team developed recommendations on how planning analysis, information, and analysts can be improved for plan revisions.

The key findings and recommendations are as follows:

- The National Forest Management Act, its attendant regulations, and policies related to national forest land and resource management plans collectively put into place the most rigorous analytic and information requirements that exist for planning by a Government natural resource agency. The first round of planning, by necessity, was a learning experience; forest planning requirements were not understood, accepted, and supported well enough to permit the development of a consistent statement of the decisions and questions that analyses were to address.

- The existing management science, economic, and resource production analyses are fundamentally sound. However, numerous technical issues need attention.

- Forest planning analyses place new demands on the content and accuracy of extant information, resulting in a lack of confidence in the data that support forest plan analyses. In addition, new information is required.

- The skills and training of analysts were adequate during forest plan development. However, communication between analysts and line and staff officers, analyst career ladders, and the recruitment and training of new analysts for plan revisions must improve.

- Most of the analysis tools needed for plan revisions currently exist; however, there is a need for increased research and development, more consistent application, and improved interpretation of the results from the available analysis tools.

Introduction

Overview

The National Forest Management Act, its attendant regulations, and Forest Service policies related to developing and implementing national forest land and resource management plans collectively require some of the most rigorous analytic and information systems found in any Government agency. These analytical and information systems were designed and developed during the forest planning effort between 1976 and 1989 and, in many cases, are complex and often difficult to use and understand.

This report examines the major analytical and information systems used in forest planning and offers recommendations for improving the analysis in future planning efforts. The report also addresses the barriers that must be overcome to implement the recommendations. The objectives of the study were to—

- Determine whether the Forest Service has the necessary analytical information to make the decisions and answer the questions addressed in the national forest plans.
- Determine the effectiveness of the analysts and the planning analysis tools and procedures used to support forest planning.
- Make recommendations pertaining to analyst expertise and to the analysis tools, information, and processes required for future forest planning activities.

Study Components and Methodology

The study focused on examining the following major components:

- The decisions made and questions addressed in forest planning to date.
- The information needed to arrive at those decisions and answers and the analytical tools and procedures used to acquire this information.
- The analyst expertise, skills, and training programs used in forest planning.

These components are discussed in light of how they evolved over the first 13 years of national forest planning. The findings come from questionnaires answered by Forest Service personnel; the results of two FORPLAN symposia, held in 1986; a review of the literature on national forest planning; and the experience of study team members in various aspects of forest planning. Also presented are recommendations related to the major components and a

discussion of research needs. A recommended approach suggests how these same planning components should be structured for forest plan revisions.

Questions and Decisions Defined by Planning Law

The purpose of analysis is to provide decisionmakers with systematic and consistent information. The questions or decisions to be addressed in a forest plan must be defined. Forest planning has evolved; the questions or decisions recognized now are different and more clearly defined than those recognized in the late 1970's.

A questionnaire was sent to each Forest Service region with a request that it also be forwarded to one-third of the national forests in each region. The questionnaire asked for information on the following five categories of questions or decisions (the words *questions* and *decisions* are used interchangeably here):

- What questions were we required to address in the forest plan? (evidence in laws, regulations, Forest Service Manual, Office of General Counsel papers, and Washington Office staff papers)
- What additional questions did we try to answer in the forest plan? (empirical evidence from the forests, regions, and Washington Office)
- What questions were we unable to answer, and why? (empirical evidence from the forests, regions, and Washington Office)
- In hindsight, what questions should we have answered in the forest plan? (empirical evidence from the forests, regions, and Washington Office)
- What questions are considered the most important, and why are they important? (empirical evidence from the forest plan appeals and the forests, regions, and Washington Office)

Responses received from 34 national forests and 6 regional offices were synthesized using content analysis procedures. A total of 1,090 comments were analyzed for this part of the study.

Analysis Tools and Information

The review also focused on who determined the information needs and how the information was produced—through theory, analytical tools, expert opinion, inventories, and models, among others. Tools and procedures were used directly or indirectly to generate information during the planning process. This study identified how, where, and by whom the tools were developed. For example, an analysis tool may have been devloped on a national forest, elsewhere within the Forest Service (by regions, RPA, or Research), or outside the Forest Service (by universities, private consultants, or interest groups).

Analysis tools and methods include any mathematical, linguistic, geometric, or logical procedure that systematically and consistently manipulates data into a form needed by a user. In the complex process of national forest planning,

information includes a wide spectrum of items that are characterized by terms such as data, inventory, or information. The national forest planning process resulted in new demands for extant information and required new or previously unavailable information. Some extant information was no longer needed.

Three questionnaires were sent to each Forest Service region with a request to use the same one-third of the national forests that responded to the questionnaire used for the first component. The management sciences questionnaire had 47 respondents, and their answers were synthesized using content analysis procedures. Those respondents were current and former regional and forest operations research analysts, some forest planners, and a few planning staff officers. The economic analysis questionnaire received 34 responses, which were synthesized through a facilitated meeting of regional economists into the major findings and recommendations discussed in this report. The resource production questionnaire had a tabular format, so the 21 responses were summarized in numerical form without content analysis procedures. In addition, at a workshop attended by 10 scientists from academia and 4 Forest Service personnel, the linkages between the theoretical and empirical definitions of the land and resource bases used in developing resource production information for forest planning were examined.

Analyst Skills and Training

Analysts are trained to use analysis tools and methods together with appropriate information and to interpret the results of the analysis. Those with adequate skills and training in using information and analysis tools and in interpreting the results can provide decisionmakers with correct, timely, and accurate information. Several aspects of the analytical expertise and skills required for national forest planning were examined: documentation and evaluation of the criteria used in selecting analysts; the training programs used to ensure that an analyst's performance is adequate for forest planning; the success of national forests in maintaining performance when individuals in analyst positions change; the strategies used to create career paths for analysts; and the strategies used to ensure that analysts remain in the jobs long enough to produce meaningful progress and adequate documentation so that subsequent analysts can efficiently carry out the next steps of analysis.

A questionnaire was sent to each Forest Service region with a request for a response from as many analysts and forest planners as possible. Responses were received from 31 analysts and 32 planners, and the results were analyzed using content analysis methods.

Research Needs

Many aspects of forest planning analysis and information require new or additional research to more adequately meet planning needs. Some of the requirements of forest planning are still being debated in knowledgeable scientific circles in terms of whether there is a theoretical paradigm to address the requirement. In other areas, theory is, or recently has become, available to support an approach to analyzing a problem. Substantial research is required to provide the basis for developing future analysis tools and to satisfy the information needs of forest planning.

The temporal and spatial scale requirements of the information needed for forest planning also were evaluated to find ways to improve the information that will be used in revising forest plans. For example, output estimates that were used may have been developed at the acre, stand, or forest level; values and costs at the forest, State, or regional level; and economic impacts at the county or State level.

The information gathered in the previously discussed components of the study was analyzed for recommending improvements. This analysis considered—

- The decisions and questions that should be made and answered during replanning.
- Additional information or modified data formats to more completely and accurately address forest planning decisions and questions.
- Additional or modified analytical tools and procedures to provide this information subject to the limits of available data.
- The expertise and skills needed by analysts for replanning.
- The research needed to ensure that new analysis tools and information will be available in the long run.

The methods used in this portion of the study involved facilitated meetings of all members of the study team. Their experiences in this study and those acquired elsewhere during forest planning or planning research and development were synthesized to identify research needs.

Data and Findings

Questions and Decisions Defined by Planning Law

Planning laws, regulations, and policies define the decisions to be made or the questions to be answered by information derived from analyses. The interpretation of the law by the parties involved in the planning process varies considerably. When asked to specify the decisions and questions they were required to address in forest planning, 28 out of 40 regional and national forest planners and analysts agreed on the following seven items that were listed in the first question of the questionnaire:

1. Forest multiple-use goals and objectives.

2. Forest-wide management requirements.

3. Establishment of management areas and management area direction.

4. Establishment of allowable timber sale quantity and designation of land suitable for timber production.

5. Nonwilderness allocations or wilderness recommendations.

6. Establishment of monitoring and evaluation requirements.

7. Project- and activity-level decisions identified in the record of decision for the forest plan and adequately disclosed for National Environmental Policy Act (NEPA) purposes in the environmental impact statement for the plan.

These seven items have recently been incorporated into Forest Service policy through forest plan appeals decisions.

Two other respondents indicated that fewer than the seven were required. In one case, item 7 above was deleted because project-level decisions were not made in that forest plan; in the other, wilderness/nonwilderness questions were not addressed because Congress passed a wilderness law for the State, taking the matter out of Forest Service jurisdiction. The remaining ten respondents left the issue unclear by not answering the question or answering only part of it.

Twenty of the 28 respondents agreeing on the required seven items felt that additional questions must be addressed; this can be achieved through additional requirements in the planning regulations, the Forest Service Manual and Handbooks, Chief's office and regional office direction and policy, other laws (for example, the Endangered Species Act and the Sykes Act), and perceived policy based on tradition. Questions that arose from issues raised during the public

involvement process were, for the most part, related to topics within the planning regulations.

Respondents thus did not agree on the questions that must be addressed in forest planning. This suggests that the actual requirements are not clearly understood by Forest Service units.

At least 12 respondents out of the total 40 indicated that they were unable to satisfactorily address at least one of the seven required items listed above. Most of the questions that could not be answered tended to be site-specific or spatial in nature. Some of the reasons given for not answering questions included difficulty with spatial analysis (particularly in FORPLAN Version I), lack of time to study the situation, incomplete inventory information, and changing planning direction.

Most respondents agreed that the first six of the seven required items listed above were among the most important questions to address in forest planning (most felt that item 7, site-specific decisions, should be the exception rather than the rule in forest plans). Respondents also felt that other questions, developed as issues, concerns, and opportunities defined during the planning process, were among the most important. On the other hand, questions stemming from national policy or direction (without direct ties to issues, concerns, or opportunities) were not listed as most important.

The most overriding impression obtained from respondents in this study was a general sense of confusion about the decisions or questions that need to be addressed in forest planning. The reasons for this confusion are reflected in the detailed findings discussed below.

Responses were about evenly split between those who felt they had answered all questions and those who believed they had done an inadequate job in answering the same questions. Some of the respondents said that even though they answered all (or most) of the questions, some were answered better than others. It was thus a matter of degree as to how well the questions were answered.

The specific questions submitted by the 40 respondents are too numerous to list in this report. They will be further enumerated in a forthcoming paper (Dyer, in progress).

It seems that the forest planning process is perceived as having worked well. Items generally cited as working well include—

- Integration of resources.
- Interdisciplinary teamwork.
- Role of issues, concerns, and opportunities in guiding forest planning.

- Public participation.
- Plans providing strategic direction.

As with any activity, the forest planning process has room for improvement. The following findings address areas where improvement is needed.

Planning Direction

Analysts at the region and forest levels indicated that planning direction changed too frequently. As for the amount of planning direction, responses ranged from "too little" to "too much." Findings elsewhere in this report suggest that the type of direction given is more important than the amount of direction.

Understanding NFMA

Because of the variability in responses to the questions/decisions questionnaire, it is apparent that the requirements of NFMA are not generally understood or consistently interpreted. Understanding has certainly improved since the passage of NFMA because of factors such as experience gained by those involved in planning, issuance of the regulations and Forest Service Manual details on planning, and appeals and court decisions, but there still is confusion about the requirements for a forest plan. There were three major findings:

- Planning problems and issues have not always been clearly defined or understood.
- The planning process and the role of analysis are generally misunderstood within the Forest Service.
- The Forest Service has not clearly defined the role of forest planning in the overall agency planning process.

Scope of Forest Planning

The discussion of planning levels in the NFMA regulations (36 CFR 219.4) does not relate to the decisions needed to implement the forest plans—another decision level. This has probably contributed to the confusion as to what decisions are being made in the forest plans and how site-specific those decisions need to be.

The scope of a forest plan is not clearly defined in the regulations or the Forest Service Manual.

There is a lack of understanding of the difference between a programmatic (forest plan) and a project (plan implementation) environmental impact statement and the NEPA requirements for each (that is, RPA, strategic, tactical, and operational or project-level planning).

The level of specificity appropriate for a programmatic environmental impact statement and strategic plan (for example, how closely it should be tied to the

ground) is not well understood. The internal Forest Service confusion in this area is reflected in the public's attitude as well.

The requirements for "proposed and probable management practices such as the planned timber sale program" (36 CFR 219.11(c)) have contributed to the confusion over the scope of forest plans. This wording suggests a level of detail that may not be appropriate for a forest plan.

There is no clear understanding or depiction of what decisions are being made in forest plans and what decisions will be made during implementation. Recent appeals decisions have clarified this somewhat, but further clarification is needed.

The confusion about site specificity in the forest plan analysis and decision process exists both within the Forest Service and among the public. Forest plan appeals and the literature (Dyer, in progress) substantiate this finding.

The regulations do not seem to require site-specific display of a timber sale schedule (36 CFR 219.16 and definition at 219.2), but interpretation of the regulations and Forest Service direction (FSH 2409.13, Chapter 42.7) and actual practice seem to imply it.

There is disagreement over the level of site specificity that is appropriate for adequate timber resource suitability analysis and whether the location of lands suited and not suited for timber production must be mapped.

The requirement for determining the optimality of clearcutting was never carried forward from NFMA into the planning regulations. Because few respondents cited the optimality of clearcutting as a question or decision addressed in forest planning, it seems that once the regulations were developed, the issue was ignored. As a result, the forest plans do not adequately address this issue. There seems to have been an unwillingness to objectively look at alternatives to clearcutting, let alone use of clearcutting only when optimal—except in a few cases—or where pressured into it by external forces (for example, appeals and litigation).

Forest Plan Revisions

Some respondents expressed concern that current regulations imply that the plan revisions be zero-based or start from a position where current plans and previous participation and work are ignored.

Forest Planning Budget

Lack of recognition of planning in the budget process contributes to the lack of acceptance and credibility of forest planning. Money for planning is siphoned from other budget categories, leading to resentment. By not accounting for the costs of planning, the Forest Service is failing to legitimize the overall concept of planning.

Analysis Tools and Information

Forest planning analysis tools and methods reviewed in this study include three broad disciplinary groups: management sciences, economic analysis, and resource production. In addition, many analysis tools and methods are available for use in plan revisions. Some results of the planning analysis study are generally true across these groupings, and they are presented immediately below. The two general topics addressed, value of the analysis and time and money constraints, were discussed by a large majority of the respondents to each of the questionnaires that were sent to the regional and forest planners and analysts. Other results tend to be unique to the disciplinary groups and are reported in the subsequent sections. The final section addresses an issue common among analysis tools and information—the need for systems development and support.

General

The Value of Analysis

The general response from analysts and planners was that the analyses in forest planning were not valued within the Forest Service organization. Several respondants cited dissatisfaction with the kind of analysis that was conducted; they merely used FORPLAN with no real understanding of the results or with any sensitivity testing. Some felt that there was no real line officer commitment to the planning process. There were six findings:

- Management sciences analysts sensed that there was a lack of commitment to forest planning and to using the analysis results for "on-the-ground" management.

- Economic analysts cited the failure to effectively communicate the role and results of economic analysis as a serious problem in the planning process.

- Resource analysts rated the resource production analyses as average for ease of use, expense, reliability, and repeatability. Poor ratings reflected the inability to make predictions with the analysis tool. Repeatability ratings were lower when analyses depended on expert opinions.

- High costs and model limitations associated with Version I of FORPLAN also reduced the value of the analyses.

- Resource analysts expressed concern about the number of assumptions that were made in the planning analyses, the lack of adequate inventory, the dependence on expert opinion in analyses, the size limitations in FORPLAN that necessitated averaging and weakened the analysis outcome, and the lack of time and money needed to complete a real resource tradeoff analysis with FORPLAN.

- Analysts and planners indicated that managers did not take the time to understand the analysis and its interpretation, that support was lacking in the region and on the forest, and that staff and managers did not want to use the analysis results.

Time and Money for Analysis

Analysts and planners felt that there was insufficient time to conduct the forest planning analysis properly. The expense of constructing and manipulating the majority of forest planning models was prohibitive, resulting in cursory and inadequate sensitivity and tradeoff analyses and insufficient scrutiny of the model results. There were five findings:

- Analysts found a prolonged time lag between data collection and development of the final forest plan, resulting in an analysis that did not match the conditions on the ground.
- Economic analysts reported that they spent the majority of their time developing analysis models and considerably less time using them to address the planning issues.
- Resource analysts indicated concern over the lack of time and money to complete an adequate resource tradeoff analysis with FORPLAN and, when such tradeoff analysis occurred, the lack of analysis of the results. They were frustrated with the limited time available for completing the analyses.
- The combined impact of all decisions on the preferred alternative could not be thoroughly evaluated or understood.
- Analysts felt that lack of funding and time limited the analysis and its usefulness.

Management Sciences

Management sciences analysis tools and methods used in forest planning include FORPLAN, transportation analysis models, and PERT/CPM techniques. FORPLAN is the central analysis tool used in forest planning. Transportation analysis models were used on some forests where transportation was important but not addressed in FORPLAN. PERT/CPM techniqes were used when planning tasks were scheduled on some forests.

Management sciences analysts who responded to the management sciences questionnaire indicated that the key issues raised during the two FORPLAN symposia of 1986 were still unresolved. Many of these issues also have been identified both by members of the study core team and by respondents to other questionnaires used in this study. From a management sciences perspective, the most important problem relates to the definition of the role of forest planning within the overall agency planning process (addressed elsewhere in this report). This problem is particularly important in the management sciences area because, without a clear understanding of the role of forest planning, it is difficult to define how best to use FORPLAN (that is, Should FORPLAN models be used for strategic and tactical planning or for strategic, tactical, and operational planning?). Other problems identified include inadequate data and unknown production functions, the representation of nonlinear relationships in a linear program, uncertainties and discontinuities, difficulties with representing

ecological considerations (that is, spatial problems and issues relating to scale) in FORPLAN models, the lack of linkages between planning and budgeting in the Forest Service, and the need to develop linkages between FORPLAN and other analysis tools.

In addition, this study identified the following new issues.

Use of FORPLAN—Despite its shortcomings, 37 of 47 respondents felt that use of FORPLAN for plan revisions and amendments should continue. There were, however, differing opinions as to how it should be used; these ranged from timber harvest scheduling only to a comprehensive development and analysisof alternatives, similar to that done on most forests in the first round. Many respondents felt that no other system is as effective for developing alternatives, conducting tradeoff and benchmark analyses, and, perhaps most importantly, providing a framework within which to structure forest planning analysis. The general consensus is that some of FORPLAN's most important limitations could be resolved by developing linkages with other systems, such as ORACLE, GIS, ecological models, and so on.

Alternatives and benchmarks—The analysis conducted in the first round of planning involved the formulation and evaluation of numerous benchmarks and alternatives. Twenty-three of 47 respondents to the management sciences questionnaire felt that, in one way or another, the number of required benchmarks and/or alternatives that must be considered was excessive. Benchmark analysis was considered useful by 13 of 47 respondents, but many of these, as well as other respondents who did not feel that benchmarks were useful, objected primarily to the number of required benchmarks. The exercise became "just another hoop to jump through." Many analysts expressed the same concerns about alternatives. It can be argued that the seemingly excessive numbers of required benchmarks and alternatives were necessary because many issues and policies were being addressed at the forest level for the first time. However, 27 of 47 respondents felt that the focus of the analysis for future plan revisions will be defined by the need to evaluate new issues or reevaluate old issues based on changed conditions. The need for examining a wide range of benchmarks and alternatives will vary among forests. The Forest Service should adjust its policy and direction relative to the scope of plan revision analyses to allow for maximum flexibility in the types of analyses conducted.

Management requirements—Twenty-five respondents felt that management requirements play an important and useful role in forest planning analysis. Such requirements are perceived as being useful for defining "sets of practices" that, at a minimum, will be carried out for various resources in the management of a forest. They also help focus the scope of planning, develop benchmark alternatives, and set the sideboards for the analysis. They force interdisciplinary teams to recognize forest conditions and critical resource needs that should be defined and analyzed.

Evolution from functional to integrated land and resource management planning—Moving from functional to integrated multiresource planning has been

difficult. However, 21 of 47 respondents felt that the management sciences tools (specifically FORPLAN) facilitated that process. Ten respondents, primarily reacting to the difficulties in Version I of FORPLAN, felt that these tools hampered the move. Respondents generally agreed that organizational and philosophical issues were far more significant impediments to this evolution than were management sciences tools.

Implementation problems—Respondents identified numerous problems with the implementation of forest plans, some of which are identical to those identified in the FORPLAN symposia and mentioned above. These problems include lack of spatial representation in the analysis (18 respondents), data quality and accuracy problems (18 respondents), representation of standards and guidelines in the analysis (14 respondents), "ground-truthing" FORPLAN solutions (16 respondents), and the need for additional technology such as GIS and ORACLE (13 respondents). Many of these problems have been addressed elsewhere in this report. The experiences both of core team members and numerous questionnaire respondents suggest that lack of ranger district involvement both in forest plan development and in ownership of the results is an even more serious source of implementation problems than the items listed above. When planning was done in isolation in the supervisor's office, the people who must implement the plan—and their superior knowledge of "on-the-ground" conditions and issues—were largely ignored.

Influence of analysis on forest planning—Thirty-four of 47 respondents said that the influence of the analysis on the decisions made in the plan was moderate to strong. While in general this was viewed as good and the analysis was viewed as helpful, concern was expressed on two points. The first was that "people took FORPLAN and its results as gospel"—that great reliance was placed on the output levels generated by FORPLAN models and that decisions were excessively tied to these findings. The second related to a lack of understanding on the part of decisionmakers of the capabilities and limitations of the analysis tools (and hence the analysis).

Information management—Thirty-one of 47 respondents identified one or more problems with existing forest planning analysis documentation and computer records. In addition, the experiences of several core team members also strongly suggest that these problems exist. The major problems are: inadequate documentation of forest planning records of assumptions, yields, and other resource relationships used in forest planning analysis; unclear or incomplete records such that new analysts could neither duplicate nor understand what had been done previously; and lost computer files composed of FORPLAN models (and those of other analysis tools), solutions (alternatives), results, and so on. Twenty-five of 47 respondents felt that the agency was not in a position to effectively capitalize on important technological advances in computer technology and information management. Many analysts also stated that while a corporate information management philosophy and standardization of information processing are both important, care must be taken to ensure that innovations and creative ideas can flourish and grow.

Transportation—The 25 respondents who conducted transportation analyses were largely satisfied with the results. Thirteen of these used FORPLAN to conduct transportation analysis (for example, by representing roading networks in their FORPLAN models), while the other 12 respondents used network analysis systems other than FORPLAN (for example, IRPM and transhipment models).

PERT/CPM—The 12 respondents who used PERT/CPM tools for scheduling planning activities found them satisfactory.

The results of the management sciences portion of this study translate into the following findings.

FORPLAN and Forest Planning

- Analysts and planners at the forest and regional levels indicated that there were problems in implementing FORPLAN results because of the analysis and data problems given above plus the fact that FORPLAN results were complex and difficult for agency personnel and the public to understand.

- There was inadequate involvement with and ownership of forest plans by district personnel.

- Forest and regional analysts felt that the expectations of many planners, analysts, and line officers were unrealistic with respect to the limitations of management sciences tools and the implications of these limitations on the results of the analyses (that is, excessive "blind faith" was placed in the results).

- Forest and regional analysts and planners felt that problems with FORPLAN analyses occurred continuously because the system was under development at the same time it was being used.

- It was the general consensus both of participants in the FORPLAN symposia and respondents to the management sciences questionnaire that, despite its limitations, FORPLAN should be used in the plan revision process.

Range of Alternatives

- There was general agreement among respondents to all questionnaires used in this study that a much better job of developing a broad range of alternatives could have been done if time had been available.

- Management sciences analysts felt that benchmark analyses were useful for framing the forest planning decision space and validating FORPLAN models.

Multiresource Considerations

- The regulations require determination of both the allowable timber sale quantity and the associated sale schedule as well as consideration of other resources; however, they do not require a balanced treatment of all forest resources in terms of schedules of practices and output production levels with associated costs and benefits.

- Many respondents to all study questionnaires identified the need to address the suitability and availability of land from a multiresource perspective.

- Management sciences analysts and FORPLAN symposia participants indicated that excessive emphasis was placed on timber resources at the expense of other resources.

- Management sciences analysts indicated that the goal of moving to a more integrated, multiresource-oriented form of management was only partially achieved and that, for the most part, Version II of FORPLAN facilitated this move (Version I, however, did not).

Management Requirements

- Management sciences analysts indicated that management requirements were useful for providing a consistent interpretation of legal requirements, facilitating tradeoff analysis and model validation, and defining the forest planning decision space.

Information Management

- On several forests, the management of forest plan information (that is, documentation, computer files, planning records, and so forth) has been inadequate, and vital information has been lost and/or critical analyses cannot be duplicated.

- Significant advances in computer, analysis, and information technologies have been occurring and will continue to occur.

Transportation

- Management sciences analysts believe that the analysis of transportation issues was effectively addressed using FORPLAN, IRPM, or transhipment models, as appropriate.

Economic Analysis

Economic analysis methods and tools of forest planning have included extensive use of FORPLAN models, a variety of efficiency-oriented analysis

techniques (cost-benefit, cost-effectiveness, present net value, and so on), and IMPLAN and community-based models for regional impact analysis. In large part, FORPLAN and analyses surrounding the application of FORPLAN have been key to the economic analyses conducted in forest planning.

While fundamentally sound, the economic analysis in forest planning can be improved. Although many of the recommendations relate to technical issues of economic analysis, several suggest managerial actions to address these issues.

Pertinent literature and Forest Service economists and analysts revealed the following common issues regarding economic analysis in forest planning, which are addressed in this section:

- Planning direction.
- FORPLAN.
- Demand and benefit values (prices).
- Supply and cost.
- Regional economic and distributional analysis.
- Planning and budgeting linkages.
- Suitable timberlands.

Planning Direction

Many economists and analysts are uncertain about the role of economic analysis and economic information in forest planning. This uncertainty stems from several sources, including frequently changing and inappropriate directives, insufficiently clear responsibilities for setting economic policies, uncertainty about the questions being addressed, lack of skills and training, inadequate data sources, and a lack of faith on the part of decisionmakers in the the analysis procedures. Several respondents had little training in economics but were assigned these duties for preparing forest plans. In spite of the criticisms, there is considerable support among economists and analysts for conducting economic analysis within the framework defined by the NFMA regulations. There are three major findings:

- Policies regarding economic analysis for forest planning have often been established in an ad hoc manner, causing confusion, a lack of focus, and sometimes a lack of clear policy. Current organizational responsibilities are a product of implementing the role of economic analysis at the same time as developing it. The lack of clear responsibilities for economic policies has impeded its integration into management decisionmaking.

- The NFMA regulations offer a useful context for conducting economic analyses, although parts could be improved. Without the structure defined by the regulations, it is likely that less economic analysis would have taken place.

- The current approach to Forest Service Manual and Handbook direction for economic analysis is too restrictive, implying that economic analyses can be undertaken without professional skills. This encourages superficial analyses and creates the impression that economic analysis is unimportant and irrelevant.

FORPLAN

Comments by economists and analysts show strong support for FORPLAN as a framework for conducting economic analysis for forest planning, even though a variety of technical shortcomings were noted. Large models were often described as unnecessarily complex. This was often attributed to the analysts' lack of skill, training, and experience. The result was a frequently unsatisfactory understanding of and ability to communicate the information obtained from the analysis. Analyses were often based on inadequate data sources. The following are the five findings:

- There is strong support for FORPLAN as a framework for conducting economic and tradeoff analysis for forest planning.

- The time and resources devoted to "developing" the economic aspects of FORPLAN models dominated efforts, in stark contrast to the models' application and use. The reasons for this included a lack of clear understanding of the problem being addressed by the analysis model; a tendency to include spurious details; insufficient skills, training; and experience in constructing large models; and the mechanical problems of data entry, telecommunications, and computer throughput.

- Large FORPLAN models were often described as unnecessarily complex. This was attributed to a lack of skill, training, and experience by analysts, which reduced their understanding of and ability to communicate the information obtained from the analysis.

- The complexities of FORPLAN models placed the burden of explaining the economic results of these models on the analysts. While often confident of their own understanding, analysts were frequently skeptical of how well others understood. Analysts were often unable to clearly communicate the information provided by FORPLAN.

- Most economists and analysts indicated a desire to perform more sensitivity analysis to improve their understanding of the economic relationships in FORPLAN models.

Demand and Benefit Values (Prices)

Resource demands have not typically been assessed as price-quantity relationships, or, if so, they have been simple relationships in which price does not vary over a range of production quantities. The maximum quantity demanded was usually portrayed with an upper-bound constraint (a "cutoff") based on expected consumption. Economists and analysts characterized the imposing of these upper bounds as often having little effect on allocation choices, although some indicated the reverse. Several respondents suggested that additional work to estimate demand relationships is needed.

Nonmarket prices apparently have played a minimal role in making explicit allocation and scheduling decisions. This is illustrated by economists' and analysts' assertions that variations in benefit values would have had little effect on allocations, but would have changed the present net value of alternatives. This minimal effect likely stems from not specifying the demand for resources as price-quantity relationships. Both confusion and wide variations in opinion were indicated about how an accounting stance for RPA nonmarket value estimates was chosen. Furthermore, analysts expressed little faith in the methods used to estimate nonmarket benefit values. Where they considered it important (for example, in the case of timber prices), forest analysts invariably estimated their own benefit values rather than use regional RPA values. Various resource benefits were often implicitly incorporated into the analysis through the extensive use of constraints. Unfortunately, the limited use of sensitivity analysis makes it unlikely that the opportunity costs of these constraints were assessed in most applications. There are five findings:

- Resource demands were not typically assessed as price-quantity relationships, but rather they were portrayed by horizontal demand schedules with an upper-bound constraint ("cutoff") based on expected consumption.

- Additional work to estimate demand relationships for many resources is needed.

- Nonmarket prices have played a minimal role in making explicit allocation and scheduling decisions in forest planning.

- Confusion and wide variations of opinion exist about which accounting stance for RPA nonmarket values should be used in forest planning. Furthermore, there is little acceptance for the methods used to estimate RPA nonmarket benefit values.

- Many nonmarket resource benefits were implicitly incorporated into the analysis through the extensive use of constraints. It is unlikely that the opportunity cost of these constraints was assessed in most applications.

Supply and Cost

Economists and analysts indicated that most cost data used in forest planning were based on historical data obtained at the forest level. In contrast, regional RPA values for benefits were typically used for most resources, with timber the main exception. Although there were wide variations, a common unit of measure for cost was cost per acre based on forest-wide averages. Some respondents noted that more site-specific cost estimates would have been helpful and that cost-per-unit output would have better matched cost estimates with benefit values. There was wide variety in the treatment of fixed and variable costs. There are three findings:

- Most cost data used in forest planning were based on data obtained at the forest level. Often, historical data were deemed unreliable.

- Although there were wide variations, a common unit of measure was cost per acre based on forest-wide averages. More site-specific cost estimates would have been more helpful and cost-per-unit output would have better matched benefit values.

- There was little commonality among the methods used to identify fixed and variable costs.

Regional Economic and Distributional Analysis

IMPLAN is regarded by economists and analysts as an adequate analysis system for economic impact analysis in forest planning. However, IMPLAN is considered insufficient for addressing community-level economic impact issues. Several economists and analysts expressed strong reservations about the quality of the data on local economic conditions used by IMPLAN. The broader issues of distributional economic and social consequences of forest plans (in general, who benefits and who pays) have received little analytical treatment, although most economists noted that these aspects underlaid many of the planning issues and should have been addressed with as much emphasis as efficiency issues. In fact, many strongly recommended that distributional analysis should be emphasized by the NFMA regulations. Respondents generally concluded that IMPLAN was not sufficient for fully addressing these distributional issues. There were wide disparities among analysts concerning the knowledge and interpretation of community stability and the agency's policies, if any, regarding it. The following are the six major findings:

- IMPLAN is an adequate analysis system for economic impact analysis in forest planning.

- IMPLAN is insufficient for addressing community-level economic impact issues.

- The quality of the data about local economic conditions used by IMPLAN is questionable and should be improved.

- Issues of distributional economic and social consequences of forest plans (who benefits and who pays) received little analysis, although these aspects underlaid many planning issues.

- IMPLAN was not sufficient for fully addressing distributional issues.

- There were wide disparities among analysts concerning the knowledge and interpretation of community stability and the agency's policies regarding it.

Planning and Budgeting Linkages

Several respondents indicated that budget constraints were used in developing forest plans, even though their use is discouraged. Although opinions varied, many indicated that these constraints were needed to develop "reasonable" and "implementable" plans. In contrast, imposing constraints on plans based on "expected" budgets limited flexibility in responding to changes in budget levels when implementing the plan. While the use of budget constraints in benchmark analysis was expressly discouraged, it seems to have further discouraged assessments of variations in a plan's allocations and scheduling with respect to possible variations in funding levels, a major problem according to economists and analysts. It was often noted that this problem was exacerbated by the perception that the land management planning and program budgeting functions are not well integrated within the agency. There are two major findings:

- Limitations on the use of budget constraints in benchmark and alternatives analysis has discouraged assessments of variations in allocations and scheduling with respect to possible variations in funding levels.

- It is perceived that land management planning and program budgeting functions are not well integrated within the agency and that this impedes plan implementation.

Suitable Timberlands

Economists and analysts indicated that FORPLAN was widely used as the basis for Stage II analysis and that ad hoc procedures were used in relatively few instances. There is little evidence that a strict "economic test" of suitability was used in most cases.

Resource Production

Resource production analyses involve all procedures, methods, and models used to estimate the responses of resources, such as forage, recreation, timber, water, and wildlife, to management actions. Here, this collection of procedures, methods, and models is referred to as *analysis tools*. Because a

spectrum of analysis tools is used, this study did not attempt to document what tools are used, but rather the quality of the tools and methods that are used. Eighteen different outputs from the planning process helped focus survey responses from regional and forest analysts and resource specialists. Thus, many of the questions will be summarized across the outputs and respondents. Pertinent responses from the planning questions and management sciences surveys also are included.

For 185 out of 279 responses, the decision to analyze an attribute was made in the forest supervisor's office. A like number of respondents indicated that the analysis tools were developed in the supervisor's office as compared to universities, Forest Service Research, regional offices, or the Washington Office. According to 121 out of 238 responses, the resource production analyses were limited by time, inventory, or analysis tools. In situations where the analysis was limited, 75 percent of the respondents indicated that the greatest limitations were inventory and analysis tools. Respondents to the questions and the management sciences surveys also cited problems with outdated inventory data, nonexistent inventory data for significant issues, and variable quality of data across the forest. Respondents to the resource production survey identified inventory as the most limiting for analyses of water, old-growth timber, carrying capacity of range, and threatened and endangered species. Lack of the necessary yield and inventory data for uneven-aged timber analyses were identified by 11 of the 47 respondents to the management sciences survey. Respondents to the resource production survey identified analysis tools as the most limiting factor for cultural resources and biological diversity; however, inventory and analysis tools were equally limiting for erosion/sediment analyses, cumulative impacts on water, visual quality, habitat capability models, and insect/disease analyses. Respondents to the questions survey related the difficulty of analyzing diversity and old growth to a lack of agreement on definitions, of acceptable measures, of skills and knowledge, and of an adequate inventory. Sixty percent of the respondents to the management sciences survey did not analyze minerals because of limitations in both inventory and analysis tools.

According to the resource production survey, development of tools by the Washington Office staff was more limited by time, while development of tools by regions and forests was more limited by the availability of adequate inventory and models. A follow-up telephone survey indicated that, when such tools were available, forests used analysis tools developed by Research; these tools primarily were related to timber. Other analysis tools, unavailable from any source, were developed in house.

Based on the resource production survey, only 143 (41 percent) of 347 outputs were analyzed within the linear programming framework of FORPLAN. Of these, 14 (4 percent) were based on yield tables that had been validated with actual forest data, 76 (22 percent) were based on untested yield tables, and 15 (15 percent) were treated as constraints in FORPLAN. Of the 204 outputs (59 percent) considered separate from FORPLAN, 90 (26 percent) were actually modeled, 52 (15 percent) were merely discussed in the plan or

environmental impact statement, and 62 (18 percent) were not analyzed in any manner. Of the 62 outputs not analyzed, 13 were identified as issues on one or more forests.

Respondents to the management sciences survey indicated that representing uneven-aged timber management prescriptions, while possible, is difficult in FORPLAN.

Using criteria such as cost, ease of use, repeatability, and reliability, respondents rated the quality of the analyses as average. Poor ratings reflected analysis tools with an inability to predict. Increased costs were associated with inadequate tools and, as cited in the management sciences survey, lack of adequate skills to develop and use analysis tools. Low repeatability ratings were associated with the expert-opinion nature of the analyses and the lack of confidence in repeating those analyses once the individuals making them had left the forest.

The 14 Forest Service and academic workshop participants concluded that the scale characteristics of planning questions and outputs were critical in analyzing resource production. Planning questions and resource outputs have an implicit spatial (geographic) and temporal (time) scale associated with their description on the land base. Humans define a spatial and temporal scale to inventory, analyze, and manage the resource. This human-defined scale may or may not be appropriate to analyze the workings of nature for producing resource outputs. Ecological hierarchy theory provides a set of rules for linking scales of natural systems with the analysis of resource production. The Forest Service has been implementing this theory empirically through the use of land classifications such as the Bailey Ecoregion approach.

The workshop participants also concluded that ecological theory can offer new insights to the management problem. Management boundaries can become barriers and disturb the behavior (dynamics) of ecological systems. Once the behavior is disturbed, attempts to mitigate the situation may be costly. For example, migratory wildlife species integrate forage supplies across a large geographic area in response to environmental changes. A boundary such as a management area can become a barrier and alter or restrict migrations. Such restriction imposes a year-round demand for forage on an area previously only seasonally grazed. Overgrazing is a possibility unless management supplements the natural dynamics with additional forage. When boundaries are selected with the least effect on ecosystem dynamics, management is maximizing the natural energy of the natural system. Where mitigation measures have been few, these premises were implicitly considered by management. In an analysis context, boundaries define the area within which resource production is analyzed, and if ecosystem dynamics are ignored, the dynamics of resource production may not be captured adequately to predict future resource production. Thus, the selection of analysis area boundaries involves an understanding of the production system for all resources. The inadequacies related to forest-wide averages discussed earlier are one aspect of this problem.

The following is a listing of resource production findings for five issues.

Multiresource Production Possibilities

- An unbalanced emphasis was placed on timber analyses as a result of the regulations, analysis tools (FORPLAN Version I), the analyst's experience, and agency tradition.

- Poor and outdated data caused a problem for analyses, plan development, and implementation.

Inventory and Analysis Tools

- The degree to which inventory or analysis tools limited planning varied by resource output—
  - Where some kind of analysis tool exists, the data needs can be specified, and the inventory is seen as deficient.
  - Where no analysis tool exists, data and inventory needs cannot be specified, and the analysis tool is perceived to be deficient.
  - When inventory and analysis tools were equally limiting, it seemed that the analysis tools were data intensive or needed careful site-specific validation.

- The degree to which inventory and analysis limited resource analyses may reflect the state of the art of modeling as well as the awareness of forest personnel about the availability of analytical tools.

- Inventory data must contain the attributes needed for planning and implementation.

Scaling of the Management Problem

- Scale characteristics of the planning questions and outputs are critical in effectively managing land and resources. Ecological hierarchy theory provides a set of rules for linking scales of natural systems with the analysis of resource production.

Maximization of Natural Energy

- Ecological theory can offer new insights to the management problem and help define management areas that diminish the disturbance on the ecological system from inappropriate boundaries.

Functional Analyses

- In most cases where mineral, oil, and gas management was an issue, the resources were not adequately addressed in forest planning analysis.
- Analyzing resource production is difficult because of the unavailability of the necessary yield and inventory data, the number of assumptions that must be made in the planning analyses, the averaging resulting from the size limitation in FORPLAN, and, in some cases, the difficulty of representing the resource in FORPLAN.
- The interpretation of the "5-year regeneration" rule varied widely across forests.

Development and Support of Analysis Tools and Methods

Analysis tools and methods are often the primary vehicles for applying research findings and other information in forest planning. Systems development and support are essential for providing the analysis tools. While research efforts will produce information and define analysis methods, they do not extend to transferring these methods, through systems development and support, into operational tools. The importance of systems development and support for planning analysis tools has not been clearly recognized within the Forest Service. Furthermore, the distinction between these activities and research is also not well understood in the agency. As a result, development efforts have often been ad hoc and inefficient.

Systems development can take many forms, but often involves constructing computer procedures that implement analysis methods. Utility programs and data base systems also are frequently needed to provide linkages among the tool, the computer platform on which the tool operates, and the analysts or users. Furthermore, these analysis tools are vulnerable to degradation in rapidly changing computer hardware and software environments, as well as in the face of changing or new theoretical and empirical findings. Consequently, it is imperative that system support activities take place. At a minimum, these activities include developing pertinent documentation on the tools and their uses, providing training and hotline services, and conducting periodic maintenance and enhancement on the tools. The effective implementation of these activities requires the recognition that both systems development and support are critical to accomplishing forest planning analyses. Significant funding and highly trained personnel resources must be committed so that effective systems development and support can become reality.

The following findings represent the collective thinking of all who were involved in this part of the overall land management planning critique (that is, respondents to all four study questionnaires, agency and nonagency participants in the workshops and symposia, and core team members):

- The role of systems development and support for planning analysis tools has not been clearly recognized within the Forest Service. As a result, development efforts have often been ad hoc and inefficient.

- The lack of emphasis on "systems development" groups within the Forest Service to develop and maintain analysis tools has reduced the agency's ability to incorporate technological and informational improvements and provide support for these tools.

- Analysis tools for forest planning should be continually maintained and improved and that these activities should not be deferred—creating the same "develop-while-using" situation that often occurred in the past.

- Tools and methods developed by Research are either not being effectively transferred to end users, or, if they are, adequate support is not being provided.

- Future planning efforts will be fraught with the same resource production modeling problems that hampered the first round of planning unless analysis capabilities are improved for all resources.

Analyst Skills and Training

Thirty-one analysts and 32 planners responded to a survey that focused on their academic background and in-service training. This background and training are related to the problems analysts had in accomplishing their assignments, in their understanding of models, and in their role in the planning process. There are four major observations relative to analyst training:

- Planners saw a relationship between an analyst's skills and that individual's role in forest planning analysis.

- Academic training in natural resources and analytical techniques is very important.

- In-service training is essential to developing competent analysts.

- Career ladders for analysts are needed.

Analysts with academic training in natural resources and analytical techniques were able to develop good FORPLAN systems, adapt to the introduction of Version II of FORPLAN, and interpret results more readily than individuals with other academic backgrounds. In particular, those with graduate degrees that stressed natural resource planning and analysis seemed best prepared for forest planning analysis.

In-service training for Version I of FORPLAN was adequate, but Version II training was less successful. Micro-IMPLAN training was generally well received. Training in modeling concepts and the role of analysis in planning, training for nonanalysts so that results of analysis can be understood and used,

and one-on-one training by experienced analysts were among the training needs identified by analysts and planners.

The absence of career ladders frustrates analysts. They perceive that the Forest Service does not value analysts or understand the role analysis can play in other facets of the agency decision-making system. This suggests that personnel policy changes are needed.

The Relationship Between Skills and the Analyst's Role

Forest planners helped define the need for and the role of analysts in the planning process. The following findings provide important insights into interdisciplinary team staffing and operation:

- In all cases, analysts were identified as essential to developing forest plans and the accompanying environmental impact statements.
- In many cases, analysts were responsible for performing or coordinating all of the analysis for the forest plan.
- Some analysts had responsibilities other than those associated with developing the forest plan.
- The academic background of planners was different from that of analysts. The terminal degree for 30 percent of the planners was a bachelor of science in forestry. Another 30 percent had terminal master's degrees with little analytical training included. Sixteen percent had bachelor's or master's degrees in landscape architecture, while 24 percent had degrees in other fields, such as engineering or economics.
- Sixty-two percent of the planners indicated that they looked for analysts with both analytical and resource management skills.
- Twenty-five percent of the planners indicated that interdisciplinary team and interpersonal skills were essential for analysts to be effective.

The Effectiveness of Academic Background in Preparing Analysts for Forest Planning Analysis

Analysts came from a variety of academic backgrounds. Most had some training in natural resources, and many had advanced degrees. Their academic background did influence the importance they placed on different planning analysis problems. The following are the findings:

- Most respondents indicated that courses with a quantitative focus (linear programming, statistics, mathematics, biometrics, computer science, and so forth) were very helpful.
- Courses emphasizing management planning also were important.
- Fifty percent of the analysts that responded had university degrees that provided both resource management and analytical skills training. This

confirms that many supervisors and planners attempted to locate analysts with both resource and analytical backgrounds.

- Most analysts felt that they understood the FORPLAN and IMPLAN systems. Even when their academic training was modest, they felt they were able to learn the models through hands-on experience and in-service training opportunities.

- The educational background of analysts did not affect the level of frustration they experienced with FORPLAN. The reasons for dissatisfaction varied, however.

- Analysts without a strong academic background in quantitative analysis expressed more concern about the mechanical details of FORPLAN.

- Analysts with strong academic analytical training tended to be more concerned about the inability of FORPLAN to address all planning issues (geographic specificity, uneven-aged management) and about the possibility that interdisciplinary team and management personnel placed too much reliance on the results from FORPLAN.

- Analysts with good resource and analytical training in their academic programs did not hesitate to use FORPLAN Version II. Those without good training were less likely to move to Version II when it became available.

- Academic training in economics and/or quantitative analysis techniques improved the ability of analysts to understand IMPLAN.

The Effectiveness of In-Service Training in Preparing Analysts

In-service training was an important part of implementing both FORPLAN and IMPLAN analysis. There is little doubt that it helped analysts develop and interpret both FORPLAN and IMPLAN models. There are eight findings:

- Generally, respondents indicated that in-service training improved their abilities.

- Analysts felt that in-service training for FORPLAN Version I was good.

- In-service training for Version II was not rated as high as that for Version I. In some cases, the criticisms were severe.

- The lack of in-service training may have limited the application of Version II by analysts without academic training in resource management and analytical procedures.

- Analysts with significant in-service training better understood IMPLAN.

- About two-thirds of the analysts indicated that more training would be desirable.
- Interestingly, analysts with less formal training in analysis were the ones that tended to *not* want additional training.
- Several analysts identified training in modeling concepts and the role of analysis in planning as the most critical training needs.

Career Ladders for Analysts

The survey results reflect significant disappointment and frustration with personnel policies related to analysts. Many feel that analysts are not valued by the agency, that they are often used and discarded, that their ability to participate in other management analysis functions is ignored, and that no career ladder is open to them. Here are the findings:

- Analysts that have been successful in finding acceptable career paths attribute their advancement to an unusual effort by supervisors or their own relentless pursuit of alternatives.
- Sixty percent of the planners responded that the forest analyst left the position during the planning analysis cycle. There were two changes of analysts in 40 percent of these cases.
- In cases where analysts felt that support for analysis was lacking, they also sensed that there was no career ladder open to them.
- Where analysis was limited to the mechanics of FORPLAN, analysts did not feel that a career ladder existed. In cases where they interacted with management, they were more positive about their careers.
- Analysts indicated that assignments outside of planning would enhance their careers.

Recommendations

Questions and Decisions Defined by Planning Law

Planning Direction

- When issuing national and regional direction for plan revision, the Forest Service should minimize the amount of confusing and inconsistent direction and thus minimize changes over time.

- Planning direction should focus on expectations for forest plans rather than on specific procedures.

Understanding NFMA

- A better understanding of the planning requirements under NFMA is needed. Any revision of the planning regulations should clarify these requirements.

- Forest Service line officers should increase their commitment to and understanding of the forest planning process.

Scope of Forest Planning

- The agency must develop the policy statements and direction necessary to clearly define the relative roles of each level of planning, the relationships among them, and the types of decisions to be made in each. The Chief's February 6, 1989, direction on implementation of forest plans could be incorporated into section 219.4 of the regulations to clarify the Forest Service decision process. This would help determine what decisions are made in forest plans and what decision are made during implementation.

- NFMA/NEPA training should differentiate between a programmatic and strategic environmental impact statement and the requirements for each.

- The agency should provide clear direction as to the level of site specificity appropriate for a programmatic environmental impact statement—for example by adding a new paragraph in the regulations (between paragraphs 219.12(a) and (b)), describing the "scope of the forest plan." Thus, in addition to defining the scope of the decision (and thus the analysis), providing necessary direction related to decisions, and defining the amount of site specificity, the forest plan would also parallel the NEPA process.

- Consideration should be given to changing the discussion of proposed and probable management practices in the regulations to clarify the level of site specificity appropriate for a forest plan (for example, the amount of

information on practices expected in each management area). This includes the display of the timber sale schedule.

- Plan display requirements should be modified to eliminate the need for site-specific timber sale information in the forest plan.
- There should be a more balanced treatment of all resources in the regulations.
- Clarification is needed on the level of site specificity required for identifying lands suited and not suited for timber production. The determination should identify the amount and types of land by management area, not specific location. Suitability determination should not be limited to the timber resource.
- Direction on optimality of clearcutting should be added to the regulations and emphasis given to alternative harvest methods as the primary methods.

Forest Plan Revisions

- The regulations should be changed to make incremental revision of forest plans the norm, unless scoping warrants a zero-based approach.

Forest Planning Budget

- The Forest Service should establish a separate budget category for forest planning.

Analysis Tools and Information

General

Value of Analysis

- There is a need to make analysis tools and, therefore, analysts more productive. Analysis must produce information within the time specified by the decision process.
- Forest-level awareness of analytical tools available in functional areas should improve. This needs further examination in each functional area.
- Forest-level acceptance of analytical tools available in functional areas should be tested. The results of such a survey would probably suggest that some forests may not be aware of certain types of analytical tools.

Time and Money for Analysis

- Regional foresters should develop a strategy for revising forest plans that includes development of a coordinated resources inventory, coordinated development of resource production tools, and sufficient training, staffing, and timeliness to avoid the problems outlined under "Data and Findings."

Management Sciences

FORPLAN and Forest Planning

- FORPLAN Version II should continue to be used as a primary tool for forest planning tradeoff analysis.
- Version II should be enhanced to allow users to represent and analyze more complex resource relationships and effects of management actions.
- The use of Version I should be prohibited during the forest plan revision process. This can be enforced by removing the system from the National Computer Center mainframe at Fort Collins as soon as possible.
- The Forest Service should continue developing and increasing its support for Workstation/Micro FORPLAN to reduce analysis costs, reduce production run bottlenecks at the National Computer Center, and provide a basis for enhancing the user friendliness of the FORPLAN system.
- The agency should understand the information needs of district-level decisionmakers and incorporate these needs and district-level involvement into the forest planning and analysis process.
- Data and analysis should be aggregated from the district-level up to ensure that the districts are properly involved in forest planning.

Range of Alternatives

- The description of required alternatives in the regulations (except those required by NFMA) should be replaced with a discussion of the need to develop a broad range of benchmarks and alternatives based on the issues, concerns, and opportunities identified in plan revision work.
- Policy and direction should be revised to recognize that in situations where incremental planning is appropriate, a reduced benchmark analysis also may be appropriate.

Multiresource Considerations

- The regulations should be revised to require balanced treatment of all forest resources, along with associated costs and benefits, when developing schedules of output production levels and management practices.
- The organizational changes needed to promote and ensure an integrated resource approach to doing business at all levels of the organization should be identified and implemented.

Management Requirements

- Management requirements analysis should be retained in the plan revisions, but the management requirements analyzed should be appropriate and the analysis (or modeling) approaches should be based on the best available research results.

Information Management

- Appropriate officials should take full responsibility for maintaining and preserving all essential forest plan information.

- Within budget and other resource limitations, the agency must keep pace with developments in computer and information-processing technology. within constraints consistent with budget and other resource limitations.

Transportation

- The agency should continue to provide the systems support necessary to ensure that extant transportation analysis systems are maintained and/or enhanced as appropriate.

Economic Analysis

Planning Direction

- An Office of Economic Policy Coordination should be established in the office of the Deputy Chief for the National Forest System. This new office would establish and clarify the procedural mechanisms for identifying, explaining, and resolving economic issues for review by Chief and Staff. The office also would act as the primary liaison between the National Forest System and research economists.

- The Office of Economic Policy Coordination should help establish a committee of regional and National Forest System staff economists. This committee would be the primary forum for developing and implementing economic policies and guidelines, clarifying the role of economics in forest planning, and resolving technical issues of economic analysis.

- The directives system for economic analysis should be revised to emphasize policies, guidelines, and standards and to deemphasize the "cookbook" approach.

- Economists should be included as members of forest interdisciplinary planning teams. The practice of assigning the role of economist to persons not adequately trained in economics should cease.

FORPLAN

- FORPLAN should continue to be used as the primary tool for economic and tradeoff analysis in forest planning.
- Research and systems development efforts should be undertaken to construct simpler, more efficient FORPLAN models.
- Training programs and systems development efforts should be implemented to improve and promote the understandability of FORPLAN models.
- Research and systems development efforts should be undertaken to make FORPLAN easier to use for sensitivity analysis and to be able to determine the opportunity cost of constraints.

Demand and Benefit Values (Prices)

- The Office of Economic Policy Coordination should establish consistent policies regarding the use of market and nonmarket benefit values (prices), various accounting stances, and demand estimation procedures in forest planning.
- Research efforts should be undertaken to improve the methods used to estimate nonmarket benefit values and demand relationships.

Supply and Cost

- The Office of Economic Policy coordination should establish consistent policies regarding the cost estimation procedures in forest planning.
- Costs should be based on "charge as worked" data.
- Forest-wide cost/acre averages should be avoided when possible. It would be preferable to use more site-specific cost/unit outputs.
- Distinctions between fixed and variable costs should be made clear.

Regional Economic and Distributional Analysis

- IMPLAN should continue to be used as the primary tool for economic impact analysis in forest planning.
- Systems development should be undertaken to refine methods for assessing community-level economic impacts, as needed, when addressing planning issues.

- Research and development should be undertaken to improve the data on local economic conditions used with IMPLAN.

- Research and development should be undertaken to improve the assessment of the community-level distributional consequences of forest plans.

- The NFMA regulations should be modified to emphasize the assessment of the distribution of costs and benefits of forest plans in addition to the evaluation of economic efficiency.

- The Office of Economic Policy Coordination should help clarify policy (if any is needed) concerning community stability.

Planning and Budgeting Linkages

- The NFMA regulations and planning directives should be modified to encourage the development of planning alternatives that describe how allocations and schedules may change with variations in funding levels.

Suitable Timberlands

- The NFMA regulations should be modified to require an economic test of timberland suitability consistent with recent litigation decisions.

Resource Production

Multiresource Production Possibilities

- The regulations should be changed to allow forests to analyze all resources equally, as appropriate to their ecological and economic situations.

- Current efforts should continue to provide more direction (definitions, measure, thresholds, inventory attributes) on ecological concerns, such as diversity and old growth.

- The linkages should improve among the resource production analyses (such as wildlife models), relational data base systems (ORACLE), FORPLAN, and GIS.

- Appropriate officials should take full responsibility for the documentation, maintenance, and preservation of all necessary forest plan information.

- The Forest Service should support the development of analytical tools for resource production, incorporating current research findings in landscape ecology. This should include tools that will affect the combined impact of all standards and guidelines on the management and operation of the forest.

Inventories and Analysis Tools

- The various inventories on forests should be aggregated in such a manner that one functional area can take advantage of data collected by another functional area.

- Current awareness and acceptance of tools now available in functional areas should increase at the forest level.

- The current analytical capability of each resource area and the ability of existing inventories to meet those analysis data requirements should be evaluated. Better inventories must be based on their ability to provide the kinds of data needed in resource production analyses.

- Resource specialists should have a complement of analytical skills. The agency should provide in-service training to improve analytical skills, add temporary staff to develop resource analysis tools when needed, and employ quantitative resource specialists.

Scaling of the Management Problem and Maximization of Natural Energy

- Analysis tools should be developed to identify the scaling characteristics of the questions, issues, and concerns and to identify the appropriate land-type configuration for resource production analyses.

Functional Analyses

- The analytical capability of all resource areas should continue to improve, and analysis tools should be upgraded as new knowledge and technology become available.

Development and Support of Analysis Tools and Methods

- The Forest Service should formally establish and assign responsibilities for systems development and support, particularly with respect to analysis tools for forest planning.

- Development efforts on analysis tools used in forest planning should be revitalized. These efforts could be enhanced through cooperative efforts among Forest Service Research, universities, and interdisciplinary development groups within the Forest Service.

- Technology transfer should be improved by developing support activities for systems developed by Research that can be used in forest planning.

- The analytical capability for all resource areas should continue to improve, and this capability should be upgraded as new theory and technology become available.

Analyst Skills and Training

A number of new analysts will have to be recruited for the plan revision process because many of the people involved in the first round of planning have either left the Forest Service or have moved to other assignments.

- Recruitment of analysts should be focused on people that have academic training in both natural resources and analytical systems. Effective recruitment may require more extensive use of cooperative education agreements.

- Emphasis on people with academic training in natural resources and planning analytical systems should not preclude the recruitment of individuals with other backgrounds. However, these individuals will require significant in-service training to develop the necessary expertise.

- Forest planning requires expertise in a number of specific systems (FORPLAN, IMPLAN, various ecological simulation models) that are usually not included in academic programs. These topics must be addressed by in-service training.

- In-service training on modeling concepts and the role of analysis in planning should receive the most emphasis in training. Some had expectations for the FORPLAN system that were simply not achievable (for example, they expected the system would produce the plan, strategic and tactical planning could be accomplished in a single system, and geographic feasibility would be ensured).

- The inability of forest staff, forest line officers, and client groups to understand and accept analysis results was frequently identified as a major problem. This suggests a need for in-service training for nonanalysts involved in planning and forest management.

- Given the range of in-service training needs, at least two related types are needed. Such training should develop strong foundations in specific models and the relationship between different components of the planning analysis system.

- While formal in-service training will provide a foundation from which analysts can proceed, it will not be sufficient to produce quality analysis that can be implemented. A support system of zone or regional analysts that follow up the more structured training sessions will be required. These trainers could respond to problems by spending time with the forest analysts as they develop and interpret their systems. This system could also be used to monitor the adequacy of analysis being done by forests.

Research Needs for Forest Planning

Analysis tools and methods are vehicles that use research findings to generate the information needed by analysts, planners, and resource specialists (users). The distinction between analytical tool development activities and the research, per se, is critical.

Overall, the problem with current agency planning analyses has two facets. First, these analyses are extremely complex, difficult to understand and communicate, and expensive. Second, the analyses have shortcomings in their capabilities, the alleviation of which with current technology would certainly increase the degree of complexity, and so on. The problem is thus to find simpler, less expensive approaches to accomplish current capabilities and at the same time expand capabilities.

Improvement of FORPLAN

The FORPLAN system is complex and difficult to use, in part because the developers attempted to incorporate features that would enable users to address the many and diverse facets of a forest planning analysis.

Analysis Detail Over Time

There are several reasons for the problems with FORPLAN model sizes and costs. One area of concern relates to the expense associated with the solution of large linear programming models. This has been addressed with some success in terms of solution procedures, as reported by Kent et al. (1987). Problems still remain, however, because the models are quite large. Current forest planning linear programming models typically incorporate a 150-year planning horizon and track inputs and outputs with full detail for this entire period. Yet it is generally agreed that the first decade is of primary importance because it is this portion of the plan that must actually be implemented.

Two approaches to restructuring planning analysis need to be investigated. One should consider the reduction in planning horizon length, probably to 50 years. The second should address the possibility of reduction of analysis detail over time. Actual case studies using national forest models should provide the basis for investigating each approach.

Linear Versus Nonlinear Approaches

One of the major contributors to the size of large FORPLAN models is the number of decision variables—in practice, ranging from 120,000 to 150,000 (Kent et al. 1987). The principal cause of this amount is that each timing choice for each prescription must be represented by a unique decision variable. An alternative is to reformulate using a nonlinear program. While this offers the advantage of eliminating the piecewise linear approximation of nonlinear

yield streams, nonlinear programming models are much more difficult to solve than linear models (Winston 1987). The crux of this research should be to determine whether the gains from reducing the model size and explicitly incorporating nonlinear relationships offset the added solution difficulties.

Enhancement of FORPLAN's Understandability and Ease of Use

Mitchell and Kent (1987), Navon (1987), and Bare and Field (1987) have pointed out that the FORPLAN system is difficult to understand, learn, and use. Specifically, FORPLAN has evolved in what might be termed a *traditional mainframe environment* (Kent and Bevers 1988). The overriding objective of this environment was systems performance, with user performance having low priority. As a result, FORPLAN input is organized into unintuitive card image formats, and FORPLAN output is produced in an equally unintuitive and inflexible wide-carriage-printer-oriented format. One of the most important trends in computing today is a reversal of emphasis from system performance to user performance (Chi 1987). Perhaps the best evidence of this reordering of priorities is the widespread usage of the recently developed term *user friendly*. This research can be described briefly as a redesign of FORPLAN input and output (the primary user interface with the system) to make them more user friendly and intuitive.

Other Research on FORPLAN

A number of other simplifications and enhancements have been identified as important. First, the need to develop procedures for quick sensitivity analysis on FORPLAN solutions is important because of the added information on insights about such solutions that can be gained from this type of analysis. A second area of importance is increased solution efficiencies for FORPLAN-generated linear programming models. Possible approaches include Karmarkers algorithm (Winston 1987) and the acquisition of vector or parallel processing hardware. A third area is the development of methods for defining and representing management requirements in a forest planning analysis. Management requirements are currently developed in a rather ad hoc manner and incorporated in FORPLAN models indirectly, usually in the form of constraints. A fourth problem is the development of a microcomputer version of FORPLAN.

Fundamentally Different Planning Approaches

In the research described above, the focus was on restructuring the analysis in forest planning while using FORPLAN and following a rational-comprehensive planning philosophy (Lindbloom 1959; Teeguarden 1987). Such has been the practice up to now. This section focus investigates alternative planning philosophies. In this investigation, FORPLAN may or may not serve as the central analysis tool, but the overall objective is to simplify the overall forest planning exercise.

Multistage/Multilevel Planning Approaches

We need to investigate approaches that decompose the forest planning problem into two or more levels or stages. One of the main causes of large FORPLAN models is that under a rational-comprehensive planning philosophy, all analysis that has any possible connection with forest planning is performed with a

single model. While the magnitude of this problem has varied from forest to forest, in all too many cases, models have been generated with FORPLAN that attempt to simultaneously address strategic planning (land allocation), tactical planning (scheduling), and operational planning (implementation) (Bare and Field 1987; Dykstra 1987). Irland (1985), Mitchell et al. (1987), and Bare and Field (1987), among others, have proposed recognizing the hierarchical nature of planning. Dress (1975) formally proposed a two-stage approach to forest planning. All these approaches might simplify forest planning and its attendant analysis. Breaking planning into stages also may serve to make it more comprehensible for those who are involved with the exercise as well as for the public.

Temporal Equity Policy Problems

To date, one of the more important features of forest planning analysis has been the incorporation of constraints designed to ensure that temporal equity conditions are met for specific outputs. The most important manifestation of this has been in the almost universal use of nondeclining yield constraints on timber harvest in FORPLAN models. The concept of even flow as applied to other outputs also has been considered; it is being considered for forage, thermal cover, and hiding cover for wildlife. The effects of these "even-flow" constraints on optimal solutions is significant. As an example, McQuillan (1986) suggested that under certain conditions, these constraints can cause decreasing harvest levels as a result of planning reanalysis every 10 years. It is generally recognized that these constraints effect harvest patterns and cause a reduction in optimal present net values (Clawson 1977; Johnson and Beuter 1977).

The focus in this area of research should be an investigation into modeling approaches that allow a relaxation of the flow constraints for timber while there are near even flow harvest levels.

Open-Ended Analysis With Stylized Guidelines and Decision Rules

If successful, the planning decomposition described above has an advantage other that the reduction of the model size. Alternative analysis approaches (besides linear programming and FORPLAN) have a greater chance of proving effective. This area of research should focus on an investigation of conducting open-ended forest planning analyses that are oriented toward stylized guidelines and solution rules. The FORPLAN analysis currently being conducted can be characterized as an acre-by-acre approach because the optimal solution from the linear programming is composed of an allocation of each acre on the forest to some management prescription (Mitchell and Kent 1987). Two problems are that the approach fails to effectively address uncertainty (Hof 1987; Kent 1980) and to view forest management as an adaptive process. As Walters (1986) pointed out, "[W]e learn about the potentials of natural populations to sustain harvesting mainly through experience with management itself, rather than through basic research or the development of general ecological theory."

Analysis techniques need to be developed that, among other things, are designed to address these two problems.

Other Research on Different Approaches

Two other approaches to restructuring the planning problem have been identified as important: (1) consideration of using simulation approaches with or instead of optimization and (2) development of methods for optimizing ecological diversity.

Linkages Among Planning Problem Components

With renewable resource planning, essentially every aspect of a problem is interrelated with every other aspect of the problem. The problem is often decomposed into different parts for the reasons of simplicity or tractability—individual outputs are sometimes analyzed independently, different levels of planning are often carried out independently, individual land areas are analyzed independently, and different types of analysis (such as optimization and economic impact modeling) are often carried out independently. These linkages and interactions are described here because they are themselves all interrelated. Thus, it is hoped that progress can be made in addressing these interactions as a whole, as well as individually.

Multilevel Interactions

Hof and Baltic (1988) and Baltic and Hof (1988) applied a multilevel model prototyped by Hof and Pickens (1986; 1987) to the National Forest System. This work suggests that there are substantial gains to be made from capturing "comparative advantages" across national forests. This would imply that "preferred alternatives" at the forest level cannot simply be added up to generate preferred alternatives at the regional level without substantial inefficiencies. Further analysis is required on this topic to assess the magnitude of the efficiencies that might be accomplished by reoptimizing at the regional level.

At this time, the primary multilevel interaction is viewed as that between forest- and regional-level planning. The multilevel modeling research outlined above also would apply, however, to watershed-district, district-forest, and regional-national multilevel interactions.

Other Research on Linkages and Interactions

A number of other interactions and linkages have been identified as being important. First, within models such as FORPLAN, individual acres or watersheds typically are treated independently. Thus, it is very difficult to model mobile resources (such as many wildlife species) and to account for the importance of spatial configurations of management actions. Second, the linkages among different analysis (such as FORPLAN, IMPLAN, GIS, and so on) are not fully developed. Third, the linkages among different agency activities (such as planning, budgeting, and plan implementation) need clarification and development. Fourth, the management of National Forest System lands clearly interacts with that of other lands (Federal, State, and private), but procedures for accounting for these interactions are basically nonexistent. All these

linkages and interactions are important weaknesses in current planning analysis capability.

Risk and Uncertainty in Resource Planning Models

The use of linear programming techniques in renewable natural resource allocation and scheduling problems has become commonplace. One of the most frequent criticisms of linear programming is that it treats all model parameters as fixed nonstochastic measurements that are known with certainty. Random variation in right-hand sides may be addressed through "chance-constrained" programming (Charnes and Cooper 1963; Hunter et al. 1976). Random objective function coefficients do not cause relatively serious problems in terms of finding a solution that optimizes the expected value of the objective function. It is the technical coefficients in the "A-matrix" of the constraint set that seem more troublesome if they are random (Pickens and Dress 1988; Wagner 1975). In renewable resource linear programming models, the technical coefficients are typically the yield coefficients. Thus, mathematical representations of risk-neutral and risk-averse optimization under conditions of yield risk and uncertainty are needed.

Many individuals have expressed concerns that linear programming does not seem to be very effective in addressing phenomena such as fire, insect and disease infestations, or other dramatic ecological changes. It is not uncommon for this shortcoming to be attributed to the fact that linear programming does not incorporate stochastic variation in the response variables with great ease. It has also been suggested that linear programming fails because it does not easily incorporate risk-averse perspectives or that it does not account for the desirability of flexibility or the undesirability of irreversible decisons. All these points are well taken; however, all these weaknesses could be remedied and the linear programming models still might not perform well in terms of modeling fire, insect and disease infestation, and so forth.

A linear programming model is based on a calculus-oriented formulation of the optimization problem, where constraints and objective functions are smooth, many times differentiable functions. That is, the basic mathematical foundation of a linear programming model includes an assumption that small changes in choice variables will result in small changes in response variables. Likewise, symmetrical reactions to small changes in choice variables are implicitly assumed. Phenomena such as fire and insect and disease infestation simply do not behave that way. They behave in fits and starts, and at times very small changes in choice variables can cause an immense impact on the ecosystem because of such a discontinuity. Managing these unstable "catastrophes" is generally more important than managing the ecosystem when it is "well behaved." Also, we are more likely to learn fundamentally new things about the ecosystem by concentrating on the discontinuities than we are from studying the smooth, slow-changing behavior that a linear programming model can handle. It will require moving into a new branch of applied mathematics called "catastrophe theory" that has developed out of topology and may show promise.

Value of Forest and Rangeland Outputs

There seems to be a general lack of confidence in extant methods for valuing nonmarket goods. Contingent valuation (survey methods) and travel cost modeling are the state of the art in determining user values. Research is needed to improve the survey methods in contingent valuation and improve confidence that reliable results can be obtained through hypothetical questioning of the public. Research is needed to improve travel cost modeling in a number of empirical areas, most particularly in addressing the value of travel time and multiple destination trips. For nonuser values (existence value, option value, and so on), theoretical research is needed to better understand these values, and empirical methods for measurement are in need of development. Conceptual research also is needed to determine how all these valuation approaches can best be applied in the forest planning context.

Scale of Forest Planning Questions and Outputs

The forest has been the level of analysis (subdivided by homogenous noncontiguous analysis areas). While much criticism focused on the use of homogenous noncontiguous analysis areas, the development of FORPLAN Version II will remove much of this criticism. Another problem is the design of analysis areas appropriate to the questions and attributes being analyzed in the planning process. The appropriate scale for one question or attribute may be the same as, larger, or smaller than another question or attribute. The development of wildlife models outside of the FORPLAN process is the result of incompatiable analysis areas across resource outputs.

The focus of this research should be to develop a method designed to screen questions for the appropriate scale of analysis, which would involve delineating scaling rules or criteria by which the scale of analysis is determined. In addition, this research should focus on the design of land units (analysis areas) appropriately scaled for the questions and attributes to be analyzed in the planning process that could be analyzed independently (as is assumed in FORPLAN). Ecological research has accumulated a body of literature on the grain and extent of ecological structure and function, such as the grain (sample frame) and extent (home range) of animal population dynamics; the recent research in hierarchy theory and landscape ecology should provide starting points.

Temporal and Spatial Distribution of Natural Disturbances on a Forest

An understanding of the effects of disturbances on the landscape is now seen as important in land management planning. Natural disturbances include fire, insect, avalanches, slides, and so on. While these disturbances have been studied in terms of their effect on vegetation, their spatial and temporal distribution across the forest landscape remain to be quantified. Techniques have been and are being developed to predict changes in the landscape (vegetation types, age class) and how resources react to these changes. Many techniques have been used in forest successional studies. An awareness of these natural disturbances could enhance management ability to produce resource outputs associated with the forest and rangeland base. Prescribed burns are one example of management simulation of a natural disturbance to bring about resource outputs associated with the natural disturbance. It is evident that

while these natural disturbances occur on the forest at all times, their existence has not been incorporated into the analysis of the future conditions of the forest, particularily in the FORPLAN model. Knowledge of the spatial scale of natural disturbances could help determine the appropriate geography for the analysis areas.

We need to quantify the natural disturbance regimes within ecosystems and across ecosystems on landscapes and to link the effects of managed disturbances with these patterns. The use of GIS will allow the forest to determine and quantify the temporal and spatial aspects of management activities. This knowledge should be linked with natural disturbances, and the impacts of both should be forecast over time using resource production models. Describing the dynamics of the forest at the landscape level could begin to link resources, such as minerals, that were not easily incorporated into the planning process.

Quantification of Resource Outputs as a Function of Vegetation and Environmental Features

The ability of functional areas to quantify resource production varied greatly. There is a serious concern about assumptions in the planning process and about the need to validate the models used to estimate resource production outputs—either in place of (such as wildlife analyses) or prior to FORPLAN analyses. There also is concern that the FORPLAN analysis was being driven by prior analyses that lacked adequate validation. In most cases, model adequacy was judged primarily on the model's ability to make predictions, a trait for which most models have not been examined.

The need for further inventory should be based on the adequacy of the current inventories to supply data for resource production analyses. The need for better models is sometimes as great as the need for better inventories.

Research should focus on the validation of existing models and, where needed, the development of resource production models, on the linkage between resource production models using a modeling framework (to begin examination of resource interactions) and/or the GIS data bases, and on the linkage between FORPLAN analysis areas and the spatially defined land base.

Cumulative Effects of Standards and Guidelines

The sum effect of standards and guidelines (developed functionally) on the forest's ability to implement the preferred alternative and manage according to the standards and guidelines has not been adequately examined in the planning process. This has led to situations where the alternative could not be implemented as originally defined in the plan.

Research should focus on analysis of the standards and guidelines in previous planning efforts using expert systems or the resource production models associated with the planning process, on how the cumulative effects of these standards and guidelines can be determined, and on the ways to address conflicts that arise when the alternative is implemented using the standards and guidelines.

The Recommended Analysis and Information Approach for Plan Revisions

A synthesis of the findings and recommendations in this report can be used to develop a near-term recommended approach for national forest plan revisions. The approach begins with a series of assumptions that establish a consistent analysis and information base for plan revisions. When these assumptions are not true on a national forest, they should be construed as a priority for full operational planning. Forest planning analysis and information systems are as dynamic as the ecosystems that we manage and the social and political arena in which we plan. This recommended approach is based on the following assumptions:

1. Plan revision or updating should be stressed rather than the zero-based approach used in developing the original forest plans.

2. The issues, questions, and problems to be addressed and the subsequent decisions to be made in the forest plan must be clearly defined and understood by all line officers, staff, and the involved public.

3. A wide variety of analytical tools are available to address the issues.

4. In addition, research findings should be effectively used by an established development-oriented task group. As a result, the analysis can be custom-designed to each forest's unique situation.

5. Integrated multiresource rather than functional inventories should be the norm.

6. All inventories should be current and accurate, with data organized into a relational data base management system linked to a GIS.

7. The GIS and inventory should be developed and maintained at the ranger district level, thereby ensuring that the data used in forest-level planning is the same data used for project-level analysis and, at the same time, giving the districts more ownership in the final plan. In summary, the expectations of the forest plans and the role that analysis and information play in their development are explicit and realistic.

Construction of the analytical models (linear programming, network analysis, growth-and-yield simulations, wildlife habitat capability models, forage production estimators, water yield simulations) should be facilitated through a direct link among the GIS, relational data base management system, and the specific model being developed. The models should be available through a framework that provides a consistent interface for the users. The choice of

models to be used is determined by the type of analysis needed and defined by the issues.

The direct linkage between the information systems (GIS and relational data base management system) and the analytical tools (such as FORPLAN) allows for an iterative process for refining the final model formulations used to conduct the analysis and to analyze alternatives.

Just as the GIS and relational data base management system can be used in early stages of the analysis, they also serve to evaluate the feasibility of results from models such as FORPLAN. Environmental effects, including cumulative effects, can be estimated with greater site specificity. The GIS, the resource data base, and the results of the analysis from the analytical tools can be used to display information useful to the decisionmakers and the involved public. If new issues or questions arise, the GIS, data base, and analytical tools could be easily modified to respond.

Ranger district involvement is critical in evaluating the technical and political implementability of the alternatives proposed at the forest-wide or programmatic level prior to a final approval of the plan. Additional tools may be used at this stage of the analysis to evaluate the operational feasibility of the alternatives. There is a direct link between the forest's budget process and the final plan. Various funding levels, below full plan implementation, should be evaluated and the implications displayed.

The final revised forest plan would be developed with the cooperation and understanding of ranger district staff (those who must implement the plan), the line officers (who make the decisions in the plan), and the involved public.

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